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Strategic planning toolset for reproduction of machine-building engines and equipment

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Abstract. This article illustrates a replica of a dynamic model of machine-building equipment. The model was designed on the basis of a 'system dynamics method' including the *Powersim Studio* toolset. The given model provides the basis and delineates the reproduction process of equipment in its natural as well as appraisal forms. The presented model was employed as a tool to explore reproduction of a wide range of engines and equipment in machine-building industry. As a result of these experiments, a variety of reproducible options were revealed which include productive capacity and distribution of equipment among technology groups. The authors' research concludes that the replica of the dynamic model designed by us has proved to be universal. This also opens the way for further research exploring a wide range of industrial equipment reproduction.

1. Introduction

Machine building is a leading field in defense industry in Russia. This industry belongs to a high-tech and innovative area of the domestic economy, which contributes not only to the economic well-being but also to the defense self-sufficiency in modern Russia. They make up to 55% of the core funding of all the enterprises. [1].

Size and general operating condition significantly influences the combination of techno-economic indicators of enterprises such as productive capacity, production quality, its competitive capacity, the level of resource efficiency and cost price. The enterprise outputs and its financial position depend on how well equipped this enterprise is and what kind of machines there are in terms of their technical excellence and operating condition.

The condition of the machines and equipment, their compliance with scientific and technological developments are formed in the process of their reproduction. The latter defines options for reimbursement of depreciation, renewal techniques, rates and their efficient use.

The machines and equipment of machine-building enterprises are also characterized by long-term service. Hence, a strategic planning of reproductive processes for the future is of primary importance.

It is crucial to employ efficient methods of decision-making support when working on strategic planning of equipment reproduction at the enterprise. This relates to both the current planning period as well as emergent alterations of the calculated planning values. Machine reproduction is a complicated process. It is impossible to employ such methods without involving special computer models to analyse planned efficiency and possible operational adjustments.

2. Methods and models

Nowadays the method of simulation dynamic modelling (SDM) has become widely disseminated when examining the behavior of large and sophisticated systems. In order to solve strategic level problems of enterprise management in SDM, a system dynamics approach is used. SDM was introduced by Jay Forrester in 1950s [2]. On the basis of the mentioned approach, a computer model of machines and equipment reproduction at machine-building enterprises was designed in *Powersim Studio* software environment.

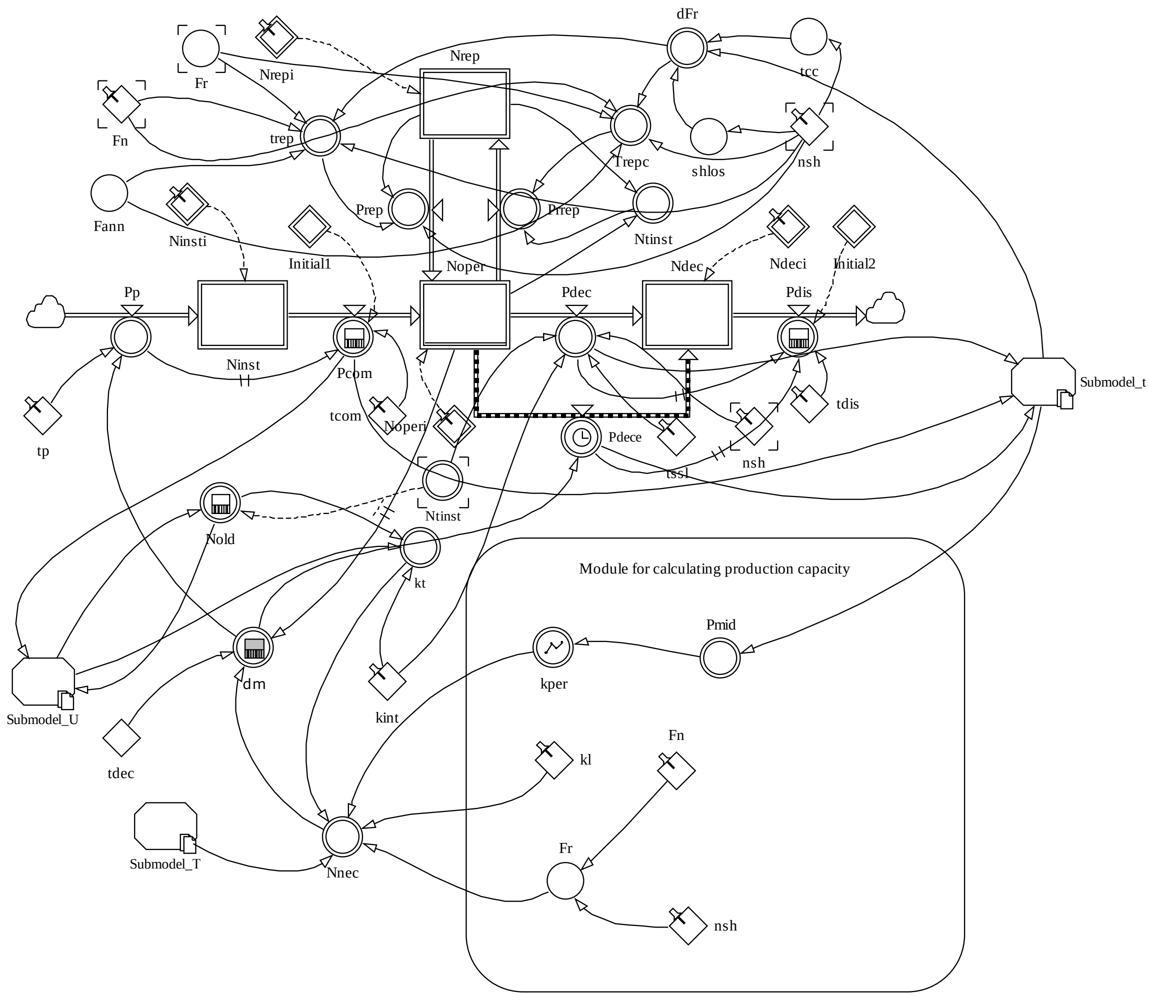

Figure 1. A diagram of flows and levels of equipment reproduction in the original form

The core of the model and the guidelines for its regulation are outlined in Figure 1. The basis of the diagram is a reflexive contour of feedback ‘Balancing under the influence of decision implementation lag’ [3]. The given contour is the contour of negative feedback. Enterprise equipment reproduction is focused on supplying necessary production capacity value. That should correspond to the production program planned for the specific period. Alteration of the production program (growth or decline) creates a gap between the necessary and the actual production capacity. Hence, it becomes necessary to take decisions with regard to the according alteration and production capacity. This can be a production capacity increase through new equipment purchase or a decline with spare equipment disposal. But it is not appropriate to purchase or eliminate machines straight away. It is necessary to wait that growth or decline in operation and production capacity is possible through repair, mounting or sending equipment for repair as well as disposal of end-of-life equipment.

This delay is an adaptation lag. It enables one to adapt the system to alteration of factors which are defined by a decision-making procedure. The decision does not impact the current level of production capacity. It only regulates modelling time. The negative feedback and decision-making delay result in an oscillating type of behavior in the given contour.

The given contour is a contour with marginal cycles of fluctuation [4]. It is characterized by global stability, i.e. the trajectory of system fluctuations does not reach infinity. At the same time, the system is not stable locally because of low disturbance (e.g. planned increase of the production program, disposal of end-of-life equipment, etc.) deviating the system from equilibrium.

3. Testing

To test the designed simulation dynamic model of machines and equipment reproduction, a department of a large-scale machine-building enterprise was chosen. The department supplies produce for oil, gas and power industries (e.g. heat-exchangers, evaporators, compressors, pumps, different types of cranes, electric motor rotors, shafts).

The data of machinery condition of the given department are represented below (Tables 1, 2).

Table 1. Machinery condition.

Index	Technological groups of equipment			
	Turning	Milling	Drilling	Boring
Carrying amount, rubs	33407580	3590240	384800	609490
Depreciation, rub	31420880	28 8830	263790	609490
Depreciation rate of the equipment, %	94	80	68.55	100
Equipment suitability rate, %	6	20	31.45	0

The presented data shows that the machines and equipment are around 90% worn out. The degree of machines suitability is less than 15%. It can be explained by the fact that the machinery has not been renewed lately. The renewal rate declined thrice.

Table 2. The age composition of the equipment.

Technological groups of the equipment	Total	Up to 10 years		From 10 to 20 years		20 years and more	
		Number	Proportion, %	Number	Proportion, %	Number	Proportion, %
Turnery	25	3	12.0	8	32.0	14	56.0
Milling	14	1	7.2	3	21.4	10	71.4
Drilling	12	3	25,0	1	8.3	8	66.7
Boring	1	–	–	–	–	1	100.0
Total	52	7	13.5	12	23.0	33	63.5

The data from aging composition of the machinery show that 63.5% of the production is provided with old-fashioned equipment and of this production 24.8% of that machinery is more than 30 years old. The average age of the equipment in technological groups for turnery is 19.4 years old, for milling

- 21.4 years old, for drilling - 19.1 years old and for boring is 25 years old. Significant proportion of obsolete equipment highlights the necessity to accelerate equipment reproduction.

Thus, the current analysis machinery condition and efficiency allows coming to the following conclusions:

– 60% of the machinery is obsolete;
– 90% of the machinery is old-fashioned.

The given enterprise was offered a 5-year long production program to supply oil, gas and power industries (Table 3).

Table 3. Production program, machinery/hours.

Parameter	Technological groups of equipment			
	Turnery	Milling	Drilling	Boring
Production program	19450	10892	9336	778

To fulfil this program, a variety of strategies (reproduction options) were calculated for the machinery. The estimated data of required investment levels according to the reproduction options (the strategies) are shown in Table 4**.**

Table 4. The required volume of investment resources according to equipment reproduction options, rub.

Option	Expenses	Option	Expenses	Option	Expenses
Expended extensive normative reproduction	62616680	Expended intensive normative reproduction	68899900	Expended intensive-extensive normative reproduction	65542860
Expended extensive accelerated reproduction	31972830	Expended intensive accelerated reproduction	47054560	Expended extensive-intensive accelerated reproduction	37243190

4. Conclusion

This study concludes that the best strategy for machinery reproduction is expended extensive accelerated reproduction. The given strategy ensures the implementation of the presented production program with the lowest investments. The most suitable form for this strategy is technical re-equipment.

Let us also conclude that the designed simulation model is a basic one. Various sub-models can be added to the mentioned model in order to calculate different characteristics and parameters. The operation of the basic model will be the source of background information for those parameters. This information, however, can be adapted to any required type. It should also be noted that the designed model can be applied to any type of an enterprise allowing one to define a generic model.

References

[1] 2016 *Industrial production in Russia* (Moscow: Federal State Statistics Service (Rosstat)) p 347
[2] Forrester J 1971 *Fundamentals of cybernetics of the enterprise: Industrial dynamics* (Moscow: Progress) p 340
[3] Forrester J 1968 *Principles of Systems* (Waltham, MA: Pegasus Communications) p 391

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[4] Stupina A A, Shigina A A, Shigin A O, Karaseva M V and Ezhemanskaja S N 2014 Automated intellectual system with the short-duration nature of feedback *Life Science* **11** 302-306